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~~PATENT APPLICATION~~

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TWO PHASE FLOW CONDITIONER FOR PUMPING GASSY WELL FLUID

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[0020] In Figure 2, an enlarged partial view of electrical submersible pump 19 is shown installed within conduit 13. Pump 19 has a cylindrical pump housing 29. Housing 29 has an axial inner passage 31. A shaft 33 is be driven by the motor 25 (Fig. 1) mounted below pump 19 and separated by the seal section 23 (Fig. 1). Housing 29 comprises an outer casing of the pump, and the outer casing has an axial centerline. Shaft 33 extends through a portion of the outer casing along the axial centerline of the outer casing. Inlet 20 locates in the bottom of the housing 29 for drawing well fluid 15 into passage 31. In the embodiment of pump 19 shown in Figures 1 and 2, pump 19 comprises an upper section 35 and a lower section 37. Upper section 35 produces most of the pumping forces and generates a large portion of head for conveying well fluid 15 up conduit 15. Lower section 37 mixes or conditions well fluid 15 before entering upper section 35. Lower section conditions well fluid 15 by creating turbulence and mixing the gaseous and liquid fluids so that gas separation is less likely to occur in upper section 35. A typical pumping section of a pump 19 can handle a well fluid 15 with a gas content of up to about 25%. Lower section 37 conditions well fluid 15 so that upper section 35 can pump well fluids with up to about 40% gas content.

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[0025] Referring to Figure 3, lower impeller 61 is shown from the side of impeller 61 that is immediately below a corresponding lower diffuser 63 in a stage 65. This side is the downstream side of ~~impllerimpeller~~ impeller 61 and well fluid 15 exits each lower impeller 61 from the side shown illustrated in Figure 3. Each lower impeller 61 has a center piece or hub 67 with a bore 69

extending axially therethrough. Bore 69 slides over shaft 33. A notch 70 formed in bore 69 matingly engages a protrusion (not shown) on the outer surface of shaft 33 to connect lower impellers 61 to shaft 33 so that rotation of shaft 33 causes impellers 61 to rotate. A plurality of impeller vanes 71 connect to and extend radially outward from the outer circumference of hub 67. Impeller vanes 71 preferably extend along an axial portion of the outer surface of hub 67 between the top, downstream side of impeller shown in Figure 3, and the lower, upstream side of impeller 71.

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[0026] As shown in Figure 4, each impeller vane 71 is curved along an angle of curvature θ between the axially upper and axially lower ends of vane 71. Referring back to Figure 3, a direction of rotation is indicated with an arrow that defines a leading edge 73 and a trailing edge 75 of each vane 71. With reference to Figures 3 and 4, leading edge 73 is located along the axially lowermost portion of vane 71, and trailing edge 75 is located along the axially uppermost portion of vane 71. Leading and trailing edges 73, 75 can be straight or curved. An angle of curvature θ defines a concave surface 81 and convex surface between leading and trailing edges 73, 75 of vanes 71. The direction of rotation defines concave surface 81 as a leading or pressure surface that engages and acts upon well fluid 15 passing through impeller 61. The direction of rotation defines convex surface 83 as a trailing or suction surface that draws more well fluid 15 into the space between impeller vanes 71 to be acted upon by concave surface 81.

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[0027] Referring back to Figure 3, a radial line L_1 extends from the radial center point of impeller 61 to the outer end of leading edge 73, and a radial line L_2 extends from the radial center point to ~~the~~ an inner end of leading edge 73 that connects to hub 67. Radial line L_1 ~~is upstream of~~leads radial line L_2 when impeller 61 rotates in the direction of rotation indicated by the arrow. Therefore, the outer end of leading edge 73 ~~is upstream of~~leads the inner end of leading edge 73. Leading edge 73 forces well fluid 15 radially inward by having the outer end of leading edge 73 ~~upstream from~~lead the inner end of leading edge 73. This action acts against the centrifugal forces imparted on well fluid 15 by the rotation of impeller 61 creates turbulence in well fluid 15 and ~~mix~~mixes or ~~condition~~conditions well fluid 15 for entry into upper portion 35. Impellers 61 also increase the fluid velocity of well fluid 15 entering upper section 35, which reduces the amount of work that upper impellers 39 must exert on well fluid 15 to pump well fluid 15 to through conduit 13.

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[0028] A radial line R extends from the center point of impeller 61 to the outer surface of hub 67. In the preferred embodiment, leading edge 73 forms a substantially straight line between outer and inner ends and is offset and substantially parallel to radial line R. Leading edge 73 is offset from radial line R by an offset distance D_1. In the preferred embodiment, trailing edge 75 is substantially parallel to leading edge 73 and radial line R, and is offset from radial line R by an offset distance D_2. As desired, an operator can change the aggressiveness or conditioning performance of impeller 71 by increasing or decreasing distances D_1 and D_2 while keeping

leading and trailing edges 73, 75 substantially parallel to radial line R. Distances D_1 and D_2 can be increased to the point that leading edge 75 is substantially tangential to hub 67. Each impeller vane 71 has a straight median line that is offset from the axis of the hub, and the straight median line is parallel to and located equidistant between leading and trailing edges 73, 75.

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[0031] Referring back to Figures 5 and 6, a plurality of diffuser blades 93 extend between the outer surface of hub 85 and outer ring 91. Diffuser blades 93 stationarily connect outer ring 91 to diffuser hub 85. Each diffuser blade comprises a portion that is curved in more than one plane. A concave side 95 and a convex side 97 of blades 93 are defined by a curvature of each diffuser blade 93.

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[0032] As best shown in Figure 7, due to the direction of rotation and placement of impeller 61 adjacent diffuser 63, concave side 95 receives well fluid 15 entering diffuser 63 from lower impeller 61, thereby defining an upstream side of diffuser blade 93. Convex side 97 is conversely defined as the downstream side of diffuser blade 91. Concave side 95 engages and redirects well fluid 15 entering diffuser 63 from lower impellers 61. In the preferred embodiment the outer end of each diffuser blade 93 leads the inner end. Additionally, as best shown in Figure 6, diffuser blades 93 are axially inclined so that the axially lower portion of blade 93 is the leading or upstream ~~edges~~edge. Therefore, the angle of incline from the upper

portion of blades 93 to the lower, leading portion of blades 93 is rearward relative to the direction of rotation of impeller 61. Blades 93 are preferably portions or segments of a sphere. Accordingly, blades 93 have a scoop-shaped profile that further mixes the liquid and gas particles in well fluid 15 while redirecting well fluid 15 to the next stage 65 or to upper section 35.